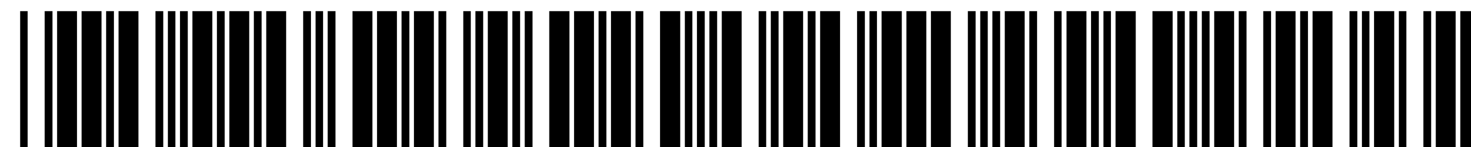

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(54) **SUSCEPTOR AND METHOD FOR MANUFACTURING SAME**

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(58) **Field of Classification Search**
USPC ...... 269/289 R, 292, 310; 428/172, 336, 408
See application file for complete search history.

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Assistant Examiner — Shantese L McDonald
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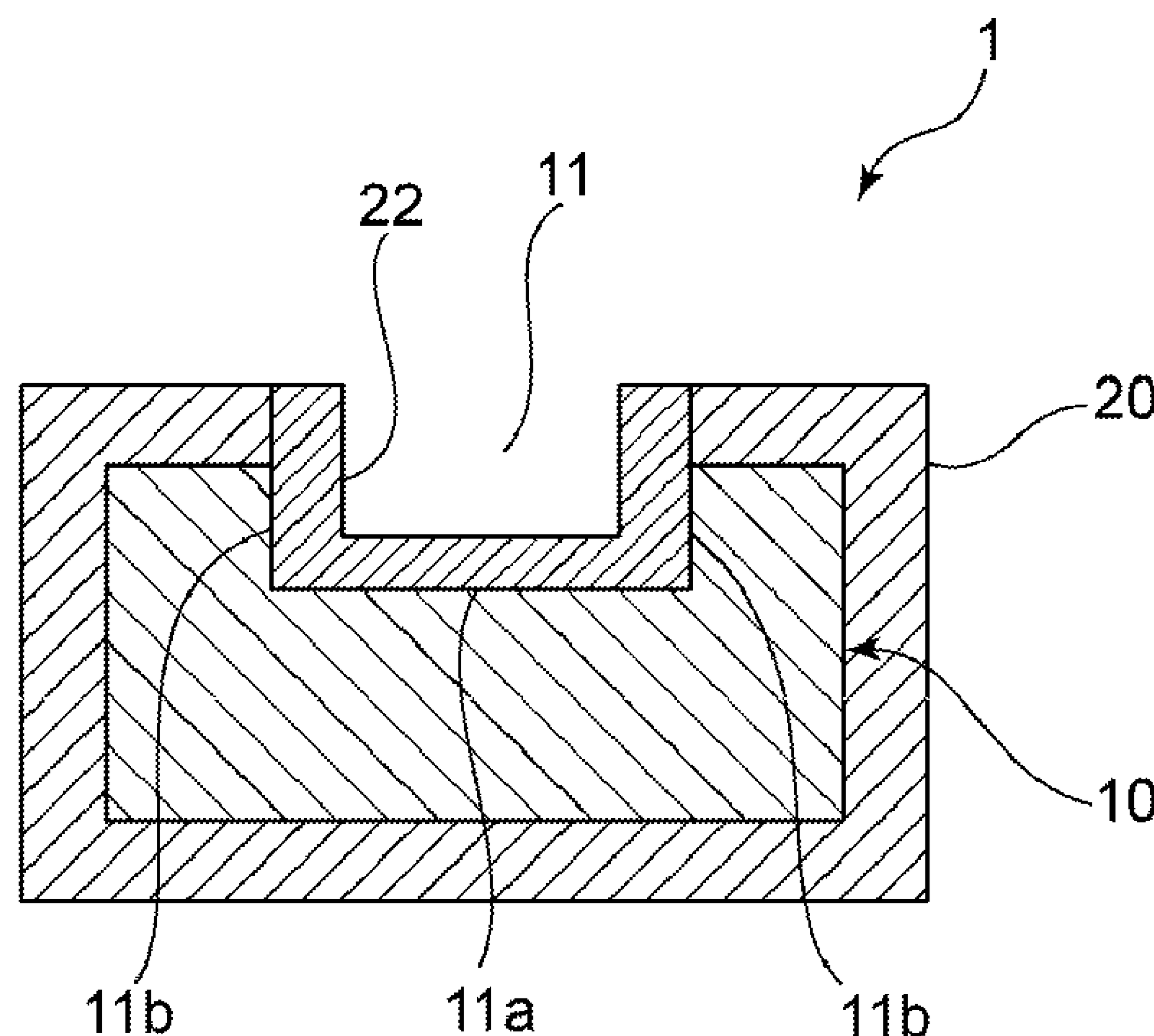
(57) **ABSTRACT**

Provided are a susceptor that, in forming a thin film on a wafer, can reduce impurities or the like adhering to the wafer and a method for manufacturing the same. A susceptor includes a base material (**10**) with a recess (**11**), a tantalum carbide layer (**22**) formed directly on a bottom surface (**11***a*) and a side surface (**11***b*) of the recess (**11**), and a silicon carbide layer (**20**) formed on a surface of the base material (**10**) except for the recess (**11**).

11 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

C23C 16/04	(2006.01)
C23C 16/458	(2006.01)
C23C 16/56	(2006.01)
H01L 21/205	(2006.01)
C23C 8/20	(2006.01)
C23C 16/06	(2006.01)
C23C 16/32	(2006.01)
C30B 25/12	(2006.01)

(52) **U.S. Cl.**
CPC ***C23C 16/042*** (2013.01); ***C23C 16/045*** (2013.01); ***C23C 16/06*** (2013.01); ***C23C 16/325*** (2013.01); ***C23C 16/458*** (2013.01); ***C23C 16/4581*** (2013.01); ***C23C 16/56*** (2013.01); ***C30B 25/12*** (2013.01); ***H01L 21/205*** (2013.01)

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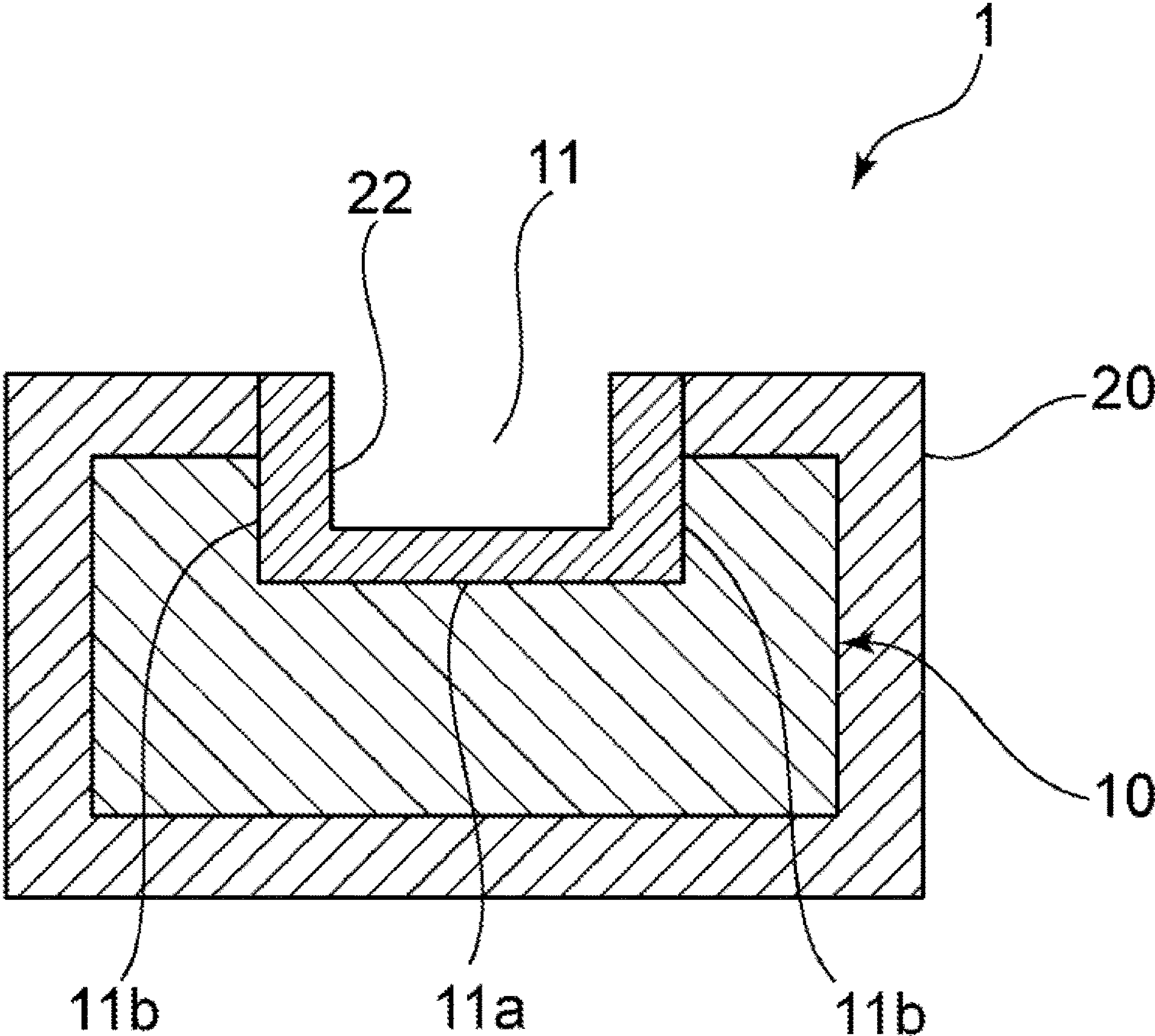
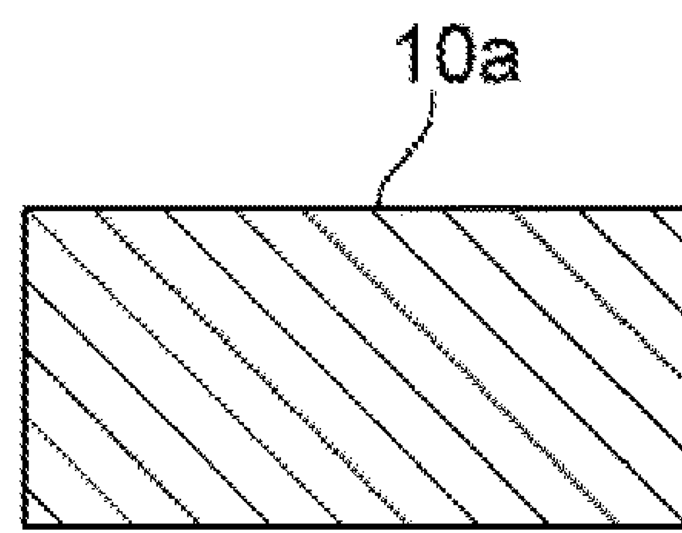
[FIG. 1.]



[FIG. 2.]

(a)



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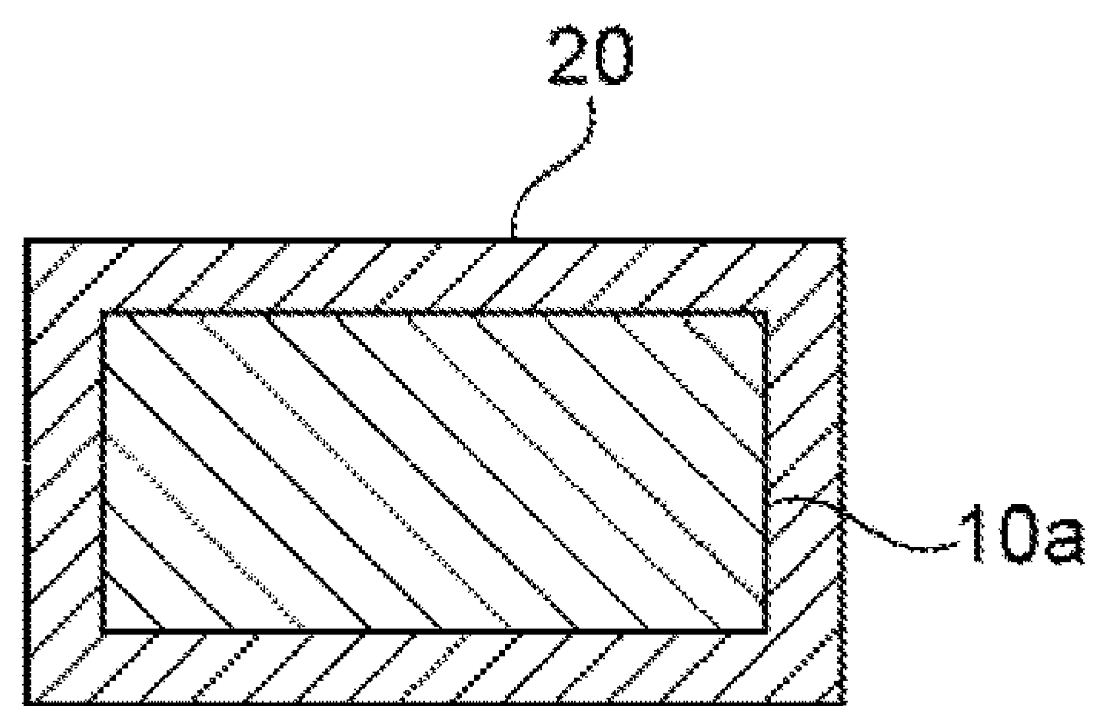

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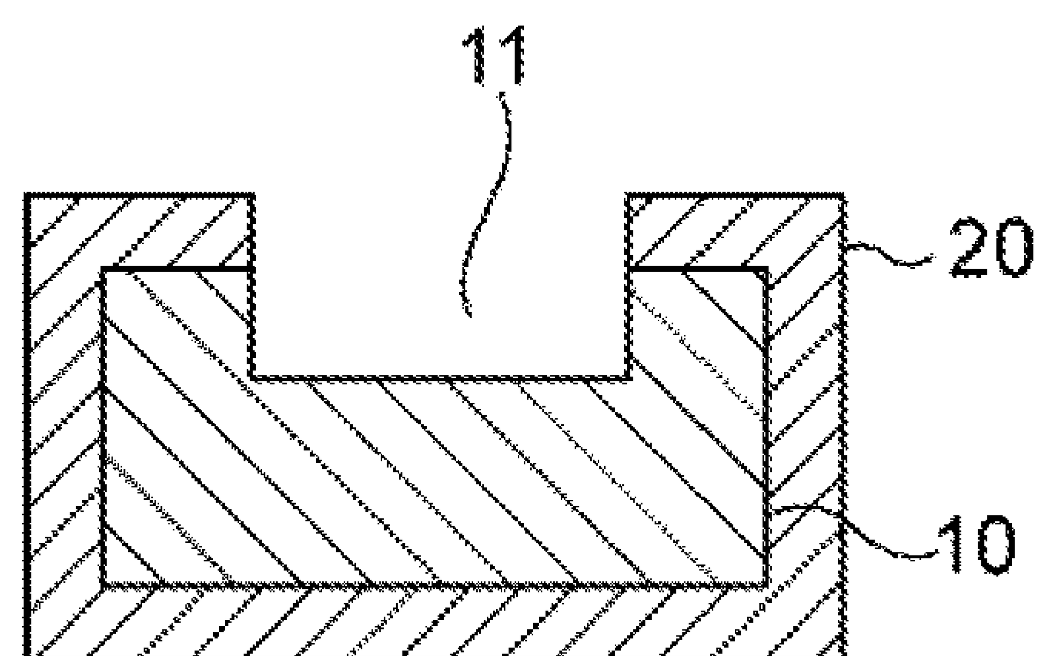
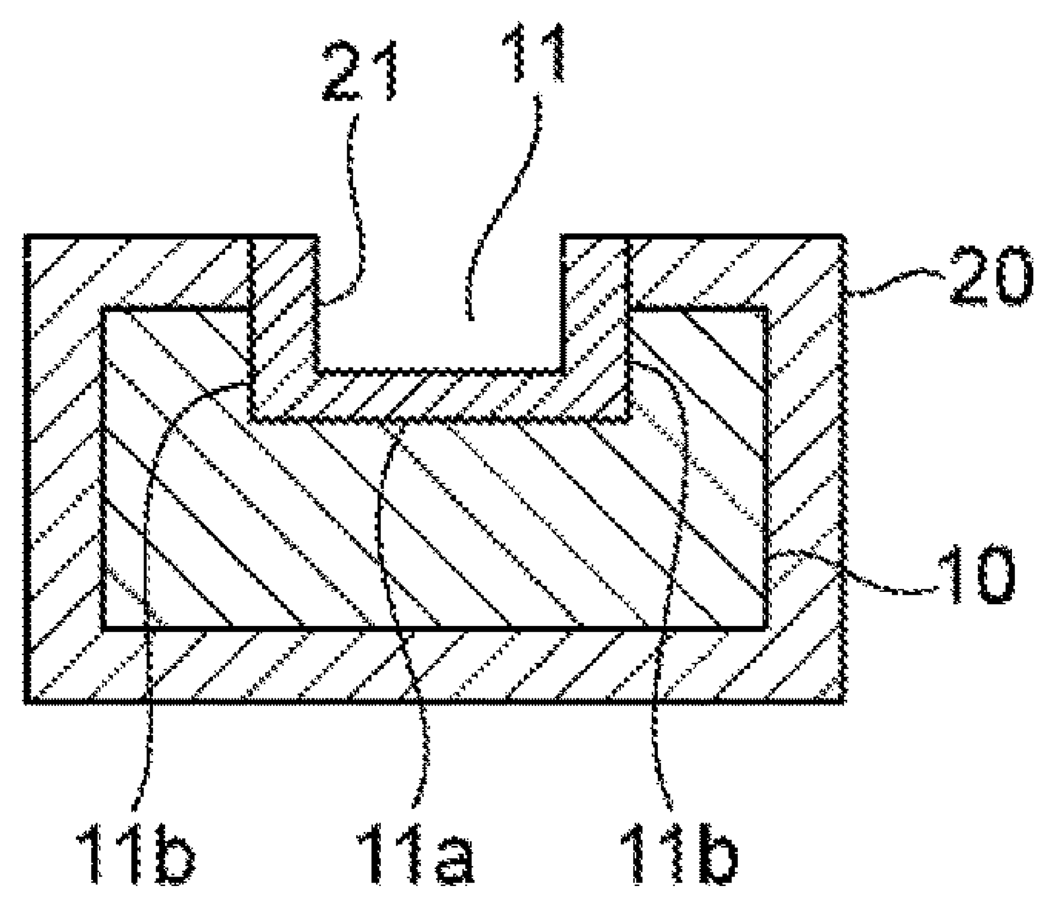
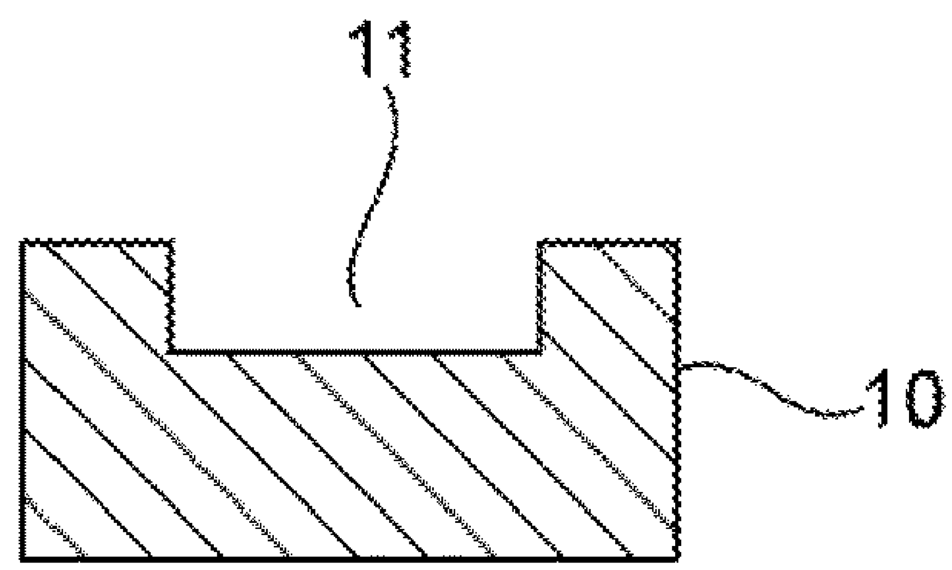


(d)



[FIG. 3.]

(a)



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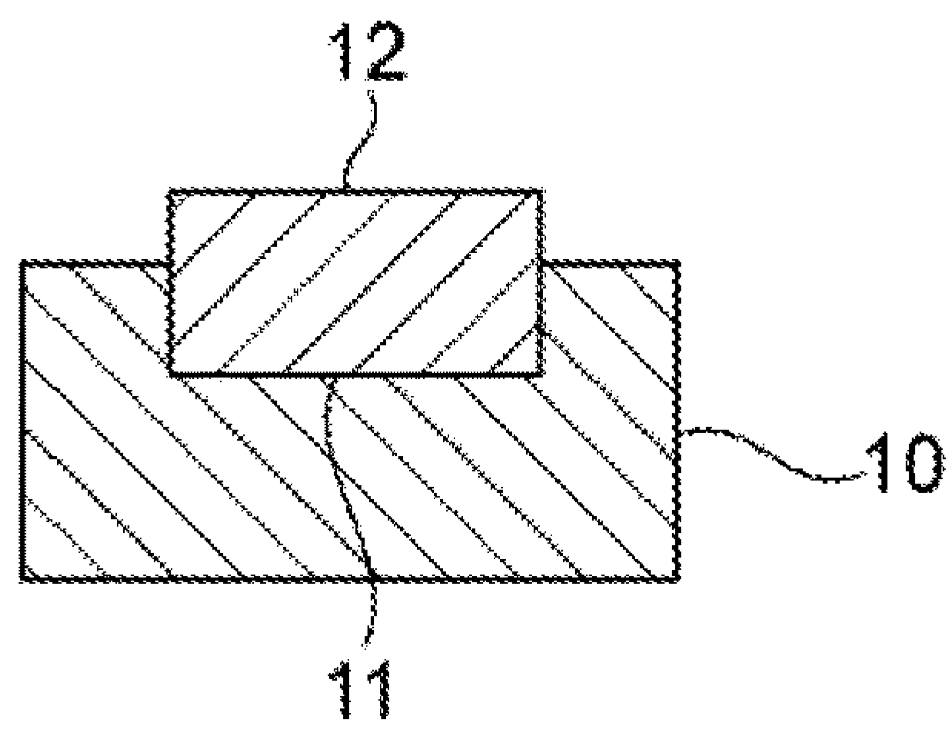
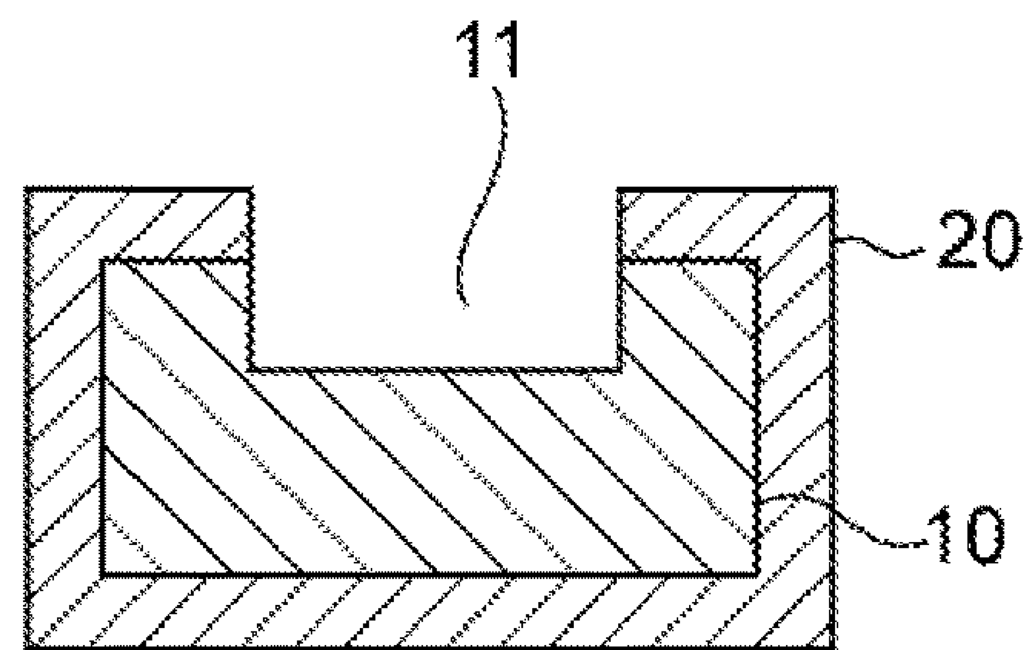
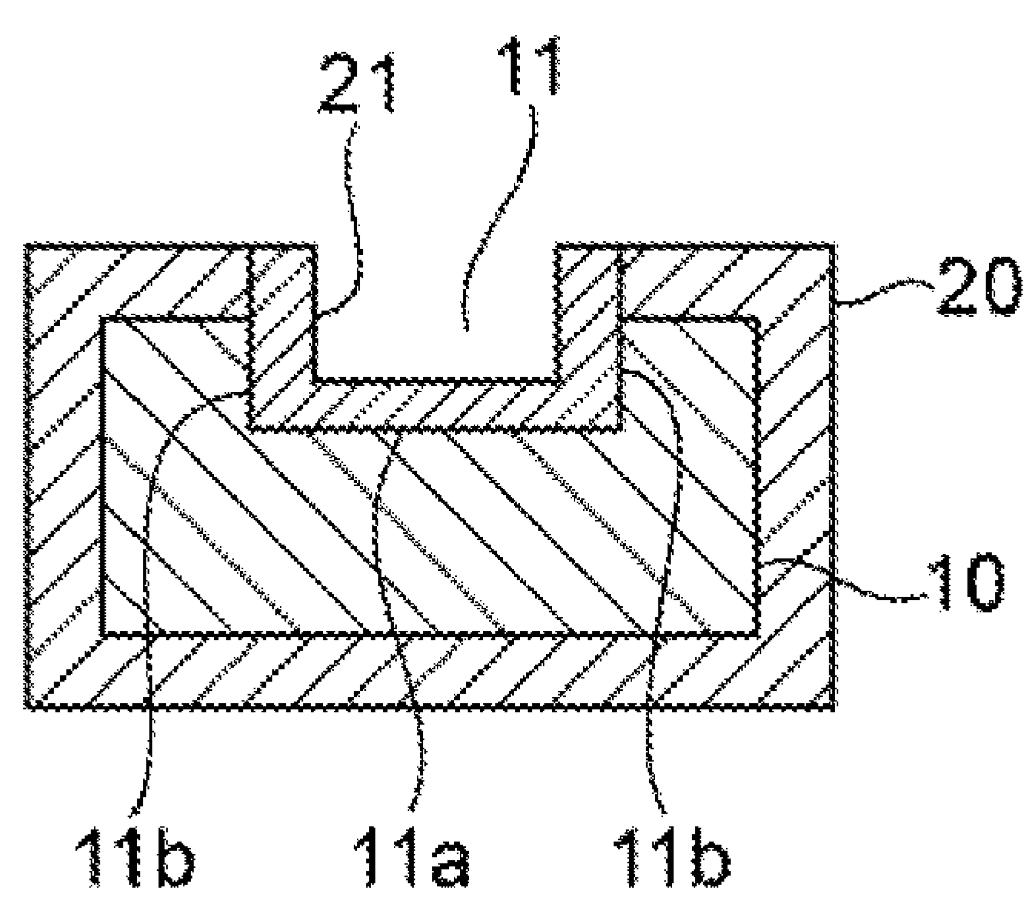


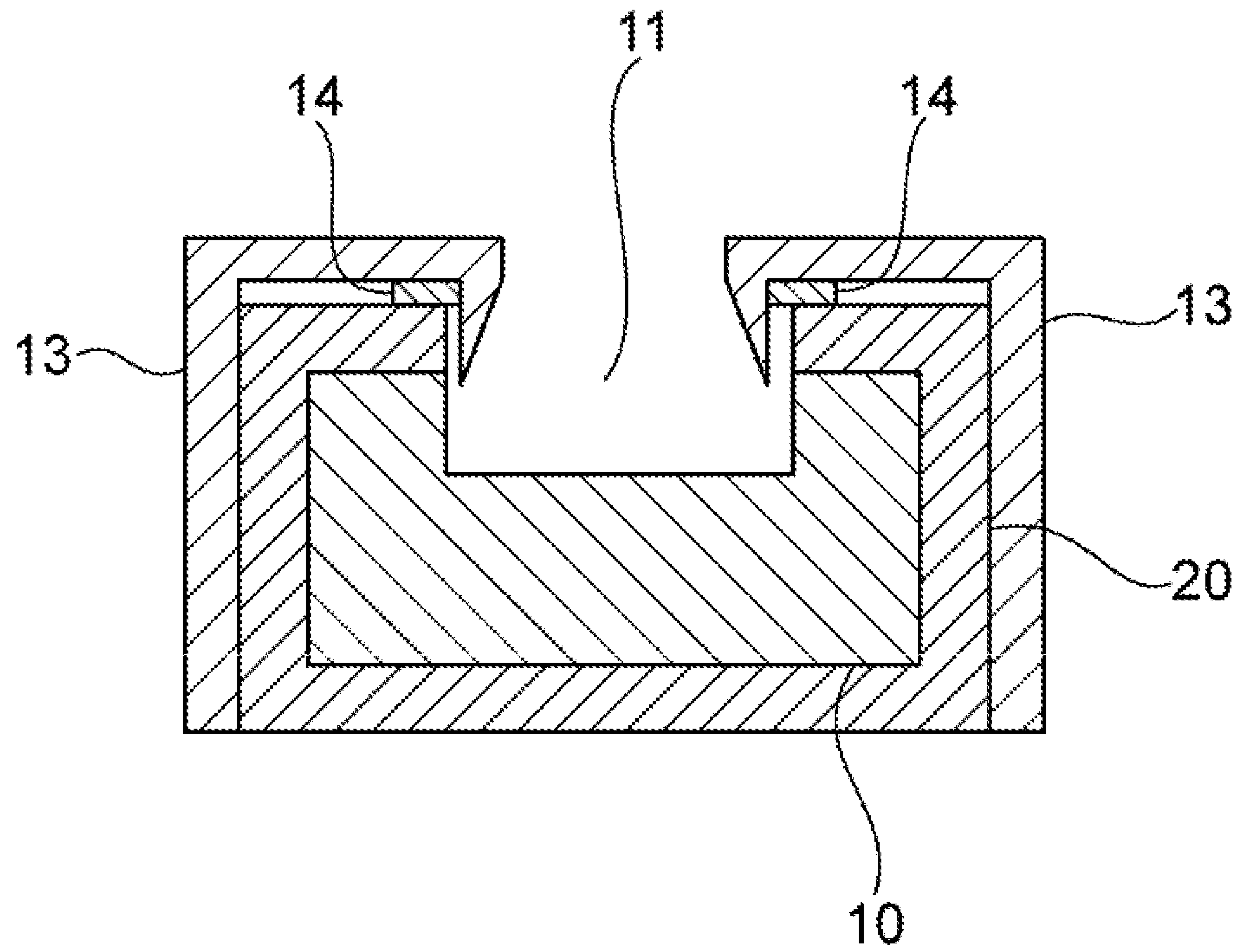
(c)



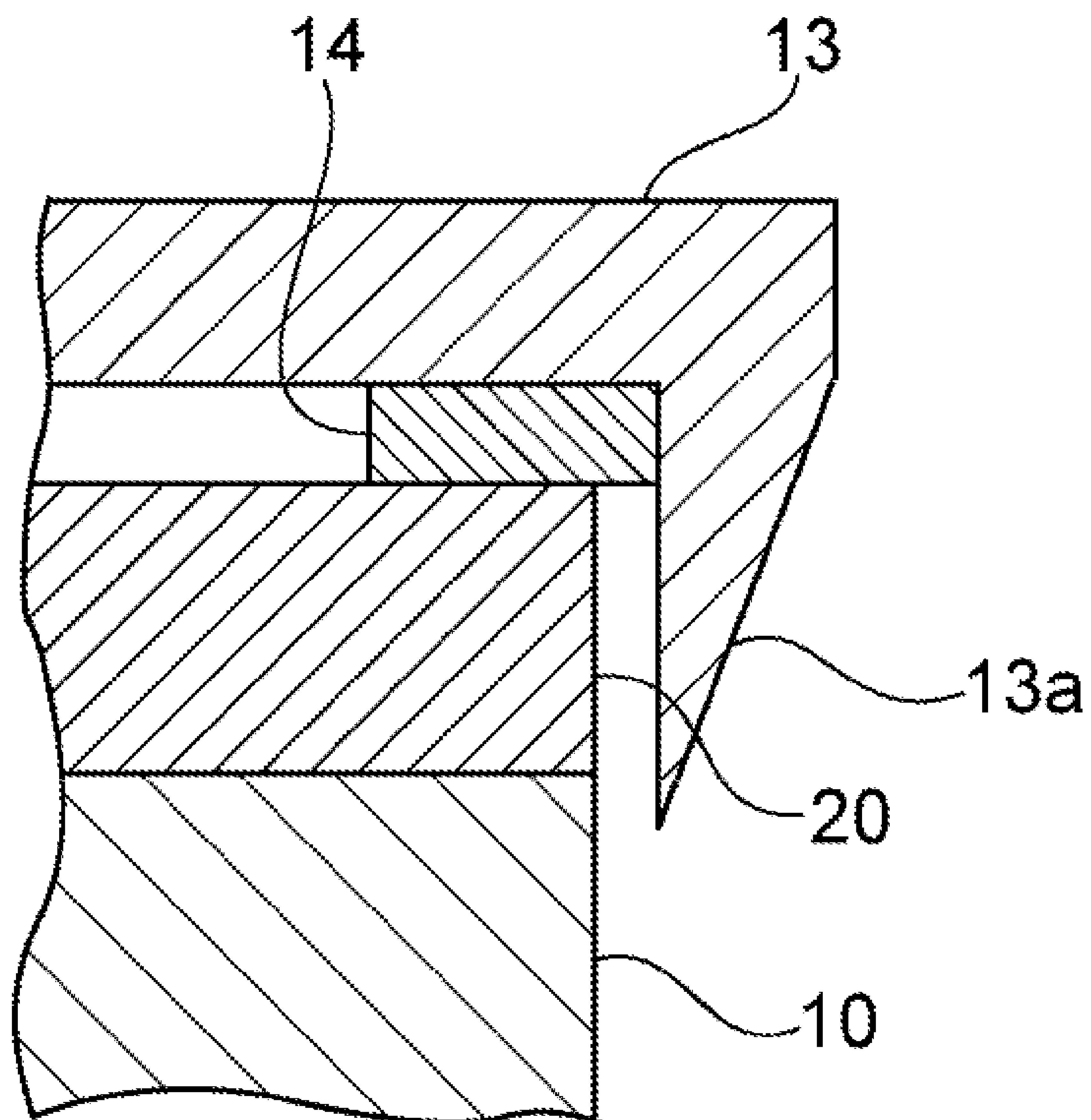
(d)



[FIG. 4.]



[FIG. 5.]



SUSCEPTOR AND METHOD FOR MANUFACTURING SAME

TECHNICAL FIELD

The present invention relates to susceptors and methods for manufacturing the same.

BACKGROUND ART

Conventionally, it is known to use, in a semiconductor manufacturing process or the like, a susceptor whose surface layer is made of silicon carbide. However, in cases such as where silicon carbide or the like is epitaxially grown on a wafer, the wafer and the susceptor are exposed to high temperatures, for example, over 1500° C. Thus, there arises a problem of adhesion of silicon carbide forming the surface layer of the susceptor to the wafer.

To solve the above problem, Patent Literature 1 proposes a susceptor in which a portion for placing a wafer thereon is formed of a detachable member made of tantalum carbide and a peripheral portion around the portion for placing a wafer thereon is formed of a detachable silicon carbide-coated graphite member.

CITATION LIST

Patent Literature

Patent Literature 1: JP-A-2006-60195

SUMMARY OF INVENTION

Technical Problem

However, since the susceptor disclosed in Patent Literature 1 is formed of a plurality of members, if has the problem of its manufacturing process being complicated and the problem of being difficult to handle.

To solve these problems, it may be conceivable to coat the entire surface of the susceptor with tantalum carbide. However, the coating of the entire surface of the susceptor with tantalum carbide causes the problem that when a silicon carbide film or the like is deposited on a wafer, the silicon carbide film deposited on the tantalum carbide layer peels off, so that resultant silicon carbide particles adhere to the wafer. Furthermore, because there is a difference in coefficient of thermal expansion (CTE) between the tantalum carbide layer and graphite forming the base material, this presents the problem of the entire susceptor warping.

An object of the present invention is to provide a susceptor that, in forming a thin film on a wafer, can reduce impurities or the like adhering to the wafer and a method for manufacturing the same.

Solution to Problem

A susceptor according to the present invention includes a base material with a recess, a tantalum carbide layer formed directly on a bottom surface of the recess, and a silicon carbide layer formed on a surface of the base material except for the recess.

In the present invention, the tantalum carbide layer may also be formed directly on a side surface of the recess.

The base material is preferably made of a carbon material and more preferably made of graphite.

A method for manufacturing a susceptor according to a first aspect of the present invention includes the steps of: preparing an original base material in which a recess is yet to be formed; forming a silicon carbide layer on a surface of the original base material; forming the recess in the original base material and removing a region of the silicon carbide layer corresponding to the recess; and forming a tantalum carbide layer on a bottom surface of the recess.

A method for manufacturing a susceptor according to a second aspect of the present invention includes the steps of: preparing a base material with a recess formed therein; forming a silicon carbide; layer on a surface of the base material except for the recess; and forming a tantalum carbide layer on a bottom surface of the recess.

In the second aspect of the present invention, the step of forming a silicon carbide layer may include the steps of: placing a masking member in the recess; forming a silicon carbide layer on a surface of the base material on which the masking member is placed; and removing the masking member from the recess after forming the silicon carbide layer.

In the manufacturing methods according to the first and second aspects of the present invention, the step of forming a tantalum carbide layer may include the steps of: forming a metal tantalum layer on a bottom surface of the recess; and subjecting the metal tantalum layer to a carburization treatment to form a tantalum carbide layer.

In the manufacturing methods according to the first and second aspects of the present invention, the step of forming a tantalum carbide layer may include the steps of: providing a masking jig to cover the surface of the base material except for the recess; and forming a tantalum carbide layer after providing the masking jig.

In the manufacturing methods according to the first and second aspects of the present invention, the tantalum carbide layer may be concurrently formed on the bottom surface and a side surface of the recess.

In the manufacturing methods according to the first and second aspects of the present invention, in order that in forming a tantalum carbide layer, the tantalum carbide layer is prevented from being formed to penetrate between the masking jig and the base material, an expandable graphite sheet is preferably placed between the masking jig and the base material.

Advantageous Effects of Invention

According to the present invention, it can be reduced that in forming a thin film on a wafer, impurities or the like adhere to the wafer.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic cross-sectional view showing a susceptor according to one embodiment of the present invention.

FIG. **2** is a schematic cross-sectional view showing a manufacturing process according to an embodiment of a first aspect of the present invention.

FIG. **3** is a schematic cross-sectional view showing a manufacturing process according to an embodiment of a second aspect of the present invention.

FIG. **4** is a schematic cross-sectional view showing a masking jig for use in the embodiment of the present invention.

FIG. **5** is a schematic cross-sectional view showing on an enlarged scale a distal end portion of the masking jig.

DESCRIPTION OF EMBODIMENTS

A description will be given below of preferred embodiments. However, the following embodiments are merely illustrative and the present invention is not limited by the following embodiments. Furthermore, throughout the drawings, members having substantially the same functions may be referred to by the same references.

FIG. **1** is a schematic cross-sectional view shoving a susceptor according to one embodiment of the present invention. A susceptor **1** includes a base material **10** with a recess **11**, a tantalum carbide layer **22**, and a silicon carbide layer **20**. The susceptor **1** is used, for example, in manufacturing semiconductors by placing a wafer on the tantalum carbide layer **22** which is a placement surface for the wafer. The tantalum carbide layer **22** is formed directly on a bottom surface **11***a* and a side surface **11***b* of the recess **11**. Although in this embodiment the tantalum carbide layer **22** is formed on both the bottom surface **11***a* and the side surface **11***b* of the recess **11**, it is sufficient in the present invention that the tantalum carbide layer **22** is formed at least on the bottom surface **11***a*. The silicon carbide layer **20** is formed on the surface of the base material **10** except for the recess **11**. In this embodiment, the silicon carbide layer **20** is formed directly on the surface of the base material **10**.

The base material **10** is preferably made of a carbon material and more preferably made of graphite. Furthermore, the base material **10** is preferably made of a material having a coefficient of thermal expansion (CTE) comparable with that of the silicon carbide layer **20** formed thereon. From these viewpoints, the base material **10** is preferably made of a material having a coefficient of thermal expansion (CTE) of 4 to 6.5/° C. (350 to 450° C.). Also from such viewpoints, the base material **10** is preferably made of a carbon material, such as graphite.

The silicon carbide layer **20** can be formed, for example, by a CVD process. The thickness of the silicon carbide layer **20** is preferably within a range from 50 μm to 300 μm and more preferably within a range from 80 μm to 160 μm.

The tantalum carbide layer **22** can be formed, for example, by forming a metal tantalum layer by a CVD process and then subjecting the metal tantalum layer to a carburization treatment. Such a formation of a tantalum carbide layer is described in, such as, for example, Published Japanese Patent Application No. 2011-153070. The thickness of the tantalum carbide layer **22** is, but not particularly limited to, preferably, for example, within a range from 10 μm to 30 μm.

In this embodiment, the tantalum carbide layer **22** is formed on the inside of the recess **11** on which a wafer is to be placed, and the wafer can be placed on the tantalum carbide layer **22**. Therefore, it is avoided that silicon carbide adheres to the underside of the wafer. Furthermore, the silicon carbide layer **20** is formed on the surface of the base material **10** except for the recess **11**. For this reason, even if silicon carbide is deposited on the silicon carbide layer **20** while silicon carbide is epitaxially grown on the wafer, the deposited silicon carbide does not peel off. Therefore, it can be prevented that the deposited silicon carbide peels into particles and the particles adhere to the surface of the wafer. Hence, in this embodiment, it can be reduced that in forming a thin film on a wafer, impurities or the like adhere to the wafer.

Furthermore, in this embodiment, the tantalum carbide layer **22** is formed directly on the bottom surface **11***a* and the side surface **11***b* of the recess **11**. Therefore, the tantalum carbide layer **22** can be formed with good adhesiveness on the base material **10**. It may foe conceivable that after the silicon carbide layer **20** is formed on the entire surface of the base material **10**, inclusive of the inside of the recess **11**, the tantalum carbide layer **22** is formed on the inside of the recess **11**. In this case, the tantalum carbide layer **22** on the inside of the recess **11** is formed on the silicon carbide layer **20**. In the case where, as in this embodiment, the tantalum carbide layer **22** is formed directly on the base material **10**, the tantalum carbide layer **22** can be formed with good adhesiveness as compared with the case where the tantalum carbide layer **22** is formed on the silicon carbide layer **20**. In addition, if the tantalum carbide layer **22** is formed on the silicon carbide layer **20**, thickness variations or irregularities of the silicon carbide layer **20** make it difficult to provide high dimensional accuracy. In the case where the tantalum carbide layer **22** is formed directly on the base material **10**, a coating thickness of the tantalum carbide layer **22** only is added onto the base material **10**, which can increase the dimensional accuracy of the recess **11**. In the case of placing a wafer within the recess **11**, the recess **11** is often required to have high dimensional accuracy, which is a great advantage in use as a susceptor.

Moreover, in this embodiment, since the silicon carbide layer **20** having a coefficient of thermal expansion close to that of the base material **10** is formed on the stir face of the base material **10** except for the recess **11**, this can prevent the susceptor **1** from warping.

The susceptor **1** according to the embodiment shown in FIG. **1** can be manufactured, for example, by manufacturing methods according to first and second aspects as described below.

FIG. **2** is a schematic cross-sectional view showing a manufacturing process according to an embodiment of a first aspect of the present invention.

As shown in FIG. **2**(*a*), an original base material **10***a* in which a recess **11** is yet to be formed is prepared. Next, as shown in FIG. **2**(*b*), a silicon carbide layer **20** is formed on the surface of the original base material **10***a*. In this embodiment, the silicon carbide layer **20** is formed on the entire surface of the original base material **10***a*. The silicon carbide layer **20** is formed by a CVD process.

As shown in FIG. **2**(*c*), next, a recess **11** is formed in the original base material **10***a* having the silicon carbide layer **20** formed thereon. The recess **11** is formed, for example, by machining. While the recess **11** is formed, a region of the silicon carbide layer **20** corresponding to the recess **11** is removed.

After the recess **11** is formed, the silicon carbide layer **20** and a portion of the base material **10** exposed in the recess **11** are preferably subjected to a purification treatment. For example, the purification treatment can be performed by a heat treatment using chlorine gas and hydrogen gas, chlorine trifluoride gas or the like. It is preferred to reduce the ash content of the portion of the base material **10** exposed in the recess **11** to 20 ppm or less by the purification treatment.

As shown in FIG. **2**(*d*), next, a metal tantalum layer **21** is formed on the bottom surface **11***a* and the side surface **11***b* of the recess **11**. The metal tantalum layer **21** is formed, for example, by a CVD process.

FIG. **4** is a schematic cross-sectional view showing a masking jig for use in the embodiment. FIG. **5** is a schematic cross-sectional view showing on an enlarged scale a distal end portion of the masking jig. In forming the metal tanta-

lum layer **21**, a masking jig **13** shown in FIG. **4** is placed to cover a region where the silicon carbide layer **20** is formed. As shown in FIGS. **4** and **5**, an expandable graphite sheet **14** is sandwiched, in a peripheral region of the recess **11**, between the masking jig **13** and the base material **10**. By sandwiching the expandable graphite sheet **14** between the masking jig **13** and the base material **10**, the metal tantalum layer **21** can be prevented from being formed to penetrate between the masking jig **13** and the base material **10**. The thickness of the expandable graphite sheet **14** is preferably about 0.1 to about 1.0 mm.

As shown in FIGS. **4** and **5**, a distal end portion **13***a* of the masking jig **13** is formed to extend toward the bottom surface of the recess **11**. This prevents displacement of the expandable graphite sheet **14**.

However, excessive suppression of penetration of a metal tantalum layer **22** in forming the metal tantalum layer **21** may cause a lack of the thickness of the tantalum carbide layer in the recess **11**. In the case where a tantalum carbide layer having a sufficient thickness is formed, the tantalum carbide layer formed to slightly penetrate and protrude onto a susceptor top surface of the silicon carbide layer **20** does not cause any significant inconvenience. The protrusion of the tantalum carbide layer onto the susceptor top surface of the silicon carbide layer **20** is preferably controlled to 5 mm or less and more preferably 3 mm or less.

In the above manner, as shown in FIG. **2**(*d*), the metal tantalum layer **21** is formed directly on the bottom surface **11***a* and the side surface **11***b* of the recess **11**.

Next, the metal tantalum layer **21** formed on the inside of the recess **11** is subjected to a carburization treatment to form a tantalum carbide layer **22**. The carburization treatment can be performed, for example, by a method described in Published Japanese Patent Application No. 2011-153070.

In the manner as thus far described, the susceptor **1** according to the embodiment shown in FIG. **1** can be manufactured.

FIG. **3** is a schematic cross-sectional view shoving a manufacturing process according to an embodiment of a second aspect of the present invention.

First, as shown in FIG. **3**(*a*), a base material **10** with a recess **11** formed therein is prepared. The recess **11** can be formed, for example, by machining or other processing.

Next, as shown in FIG. **3**(*b*), a masking member **12** is placed in the recess **11** of the base material **10**. The masking member **12** used is preferably one having a coefficient of thermal expansion close to that of the base material **10** so that when heated, no gap is formed between itself and the recess **11**. In this embodiment, the masking member **12** is formed using the same type of graphite as graphite forming the base material **10**.

Next, a silicon carbide layer **20** is formed on the surface of the base material **10**. The silicon carbide layer **20** is formed by a CVD process. Although the silicon carbide layer **20** is also formed on the masking member **12**, a state shown in FIG. **3**(*c*) is reached by removing the masking member **12** after the silicon carbide layer **20** has been formed. In this state, like the first aspect, the silicon carbide layer **20** is preferably subjected to a purification treatment.

Next, like the first aspect, as shown in FIG. **3**(*d*), a metal tantalum layer **21** is formed on the bottom surface **11***a* and the side surface **11***b* of the recess **11**.

Next, like the first aspect, the metal tantalum layer **21** formed on the inside of the recess **11** is subjected to a carburization treatment to form a tantalum carbide layer **22**.

In the above manner, the susceptor **1** according to the embodiment shown in FIG. **1** can be manufactured.

Furthermore, in the case where a material having a linear expansion coefficient approximating that of the silicon carbide layer **20** is selected as the base material **10**, if the tantalum carbide layer **22** is formed at, for example, 1800° C. and then cooled to room temperature, a difference in linear expansion coefficient between silicon carbide and tantalum carbide may cause production of fine cracks in the tantalus carbide layer **22**. Because the base material **10** is exposed in the cracks, its contact with a reaction gas may cause, for example, corrosion of graphite of the base material **10**. However, when the susceptor **1** is used as a susceptor for SiC epitaxial growth, the reaction temperature rises to about 1500° C. to about 1700° C. Thus, the extended cracks are filled during the reaction by the tantalum carbide layer **22** having expanded, so that the corrosion of the base material **10** can be prevented.

By applying the usage as described above, regardless of the linear expansion coefficient relation between the base material **10** and the tantalum carbide layer **22**, an appropriate material can be selected for the base material **10** to form a susceptor.

In this usage, the difference between the formation temperature and the service temperature of the tantalum carbide layer is preferably not higher than 300° C. and more preferably not higher than 200° C.

Although the description of the method for manufacturing a susceptor according to the present invention has been given by taking as examples the method according to the first aspect shown in FIG. **2** and the method according to the second aspect shown in FIG. **3**, the present invention is not limited to these methods.

Furthermore, although the description of the susceptor according to the present invention has been given by taking as an example the susceptor according to the embodiment shown in FIG. **1**, the present invention is not limited to this.

REFERENCE SIGNS LIST

1 . . . susceptor
10 . . . base material
10*a* . . . original base material
11 . . . recess
11*a* . . . bottom surface
11*b* . . . side surface
12 . . . masking member
13 . . . masking jig
13*a* . . . distal end portion
14 . . . expandable graphite sheet
20 . . . silicon carbide layer
21 . . . metal tantalum layer
22 . . . tantalum carbide layer

The invention claimed is:

1. A susceptor comprising:
a base material with a recess;
a tantalum carbide layer formed directly on a bottom surface of the recess; and
a silicon carbide layer formed directly on a surface of the base material except for the recess.

2. The susceptor according to claim **1**, wherein the tantalum carbide layer is also formed directly on a side surface of the recess.

3. The susceptor according to claim **1**, wherein the base material is made of a carbon material.

4. The susceptor according to claim **3**, wherein the base material is made of graphite.

5. A method for manufacturing the susceptor according to claim **1**, the method comprising the steps of:

preparing an original base material in which the recess is yet to be formed;

forming the silicon carbide layer on a surface of the original base material;

forming the recess in the original base material and removing a region of the silicon carbide layer corresponding to the recess; and

forming the tantalum carbide layer on a bottom surface of the recess.

6. The method for manufacturing the susceptor according to claim **5**, wherein the step of forming the tantalum carbide layer comprises the steps of:

providing a masking jig to cover the surface of the base material except for the recess; and

forming the tantalum carbide layer after providing the masking jig.

7. The method for manufacturing the susceptor according to claim **6**, wherein in the step of forming the tantalum carbide layer, an expandable graphite sheet is placed between the masking jig and the base material.

8. The method for manufacturing the susceptor according to claim **5**, wherein in the step of forming the tantalum carbide layer, the tantalum carbide layer is concurrently formed on the bottom surface and a side surface of the recess.

9. A method for manufacturing the susceptor according to claim **1**, the method comprising the steps of:

preparing the base material with the recess formed therein;

forming the silicon carbide layer on a surface of the base material except for the recess; and

forming the tantalum carbide layer on a bottom surface of the recess.

10. The method for manufacturing the susceptor according to claim **9**, wherein the step of forming the silicon carbide layer comprises the steps of:

placing a masking member in the recess;

forming the silicon carbide layer on a surface of the base material on which the masking member is placed; and

removing the masking member from the recess after forming the silicon carbide layer.

11. The method for manufacturing the susceptor according to claim **5**, wherein the step of forming the tantalum carbide layer comprises the steps of:

forming a metal tantalum layer on a bottom surface of the recess; and

subjecting the metal tantalum layer to a carburization treatment to form a tantalum carbide layer.

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